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ABSTRACT

A flexible surface disc device serves as the basis for the design of a computer operated multi-user shared hardware audio response system. The device employs a slow moving flexible, air supported surface in contact with a large number of heads. Relatively instantaneous distribution of audio from any portion of the disc to the users in accomplished through pulse amplitude and digital techniques. Analog recording and fixed heads in contact with the flexible surface allow for a reasonable recording capacity and general design economy. A simple scheme for switching heads electronically permits recording messages longer than one turn of the disc. In the report, a description of a system currently under development is presented by means of a brief account of its components and its operation during recording and playback. Some of the salient aspects of the design of the overall system and the new disc component are also included. (Author)

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A MULTI-USER SHARED HARDWARE AUDIO RESPONSE SYSTEM

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SHARS

A Multi-User

SHARED HARDWARE AUDIO RESPONSE SYSTEM

Utilizing a New Flexible Surface Disc Device

Brian Voth 7/69

Preface

Up to the present, other than a few modest attempts, little has been done to implement multi-user systems with audio response capability. Part of the reason for this is that contemporary equipments employing digital storage devices have shown uninviting limitations in multi-user applications. Typically they can attend to one or very few users simultaneously. Other equipment employing analog devices show similar limitations.

To try to adapt any of the devices to wider use is to become aware of the considerable expense in time, money, or size that is required to do so. All things considered, it appeared at least as expedient to try to devise a new system as it was to re-work currently available hardware. This being the case, a new flexible surface disc and multi-user shared hardware system was devised.

Noteworthy in the design of the disc and response system are the economies afforded. With regard to the disc, the exploitation of the principles of direct recording and flexible surface disc operation have resulted in a disc of reasonable capacity and cost as well as being easy to handle. Regarding the overall system, the exploitation of the techniques of hardware sharing promises equipment savings important to multi-user applications.

Although the response system project is presently supported by the Computer-based Education Research Laboratory at the University of Illinois, it is actually being developed at its sister laboratory, the Coordinated Science Laboratory, also at the University of Illinois. Several members of the latter laboratory have helped in its evolution thus far. In this regard, the author wishes to express his thanks to J. Stifle for discussions and help with the logical design of the system. Also, the author wishes to express his indebtedness to J. Cummings for his valuable suggestions and help regarding the forming of the disc cavities by way of chemical milling techniques. Thanks are due to G. Bouck for his skillful processing of the mechanical assemblies of the disc equipment, and to F. Holy and Mike Johnson for their help with the electrical assemblies. The author is also grateful to R. MacFarlane, J. Gladin, and J. Anson for their help in preparing this report.

TABLE OF CONTENTS

LIST OF FIGURES

CHARACTERISTICS

Access Times:	Recording: 2 to 18 seconds, 10 seconds ave. random. Playback: ∅ to 1 second, 1/2 second ave. random.
Audio Storage:	Capacity: 65,472 one sixty-fourth second increments (about 17.1 minutes total) Record format: Variable length records, end-to-end storage. Loading: Typically by changing discs requiring 30 seconds, or re-recording. Operation: Multi-user playback, single user recording (Multi-user playback with recording possible) monaural only.
Audio Performance:	System bandwidth: ±6DB 100 to 9,000 Hz or better Flutter: .16% or better S/N & Distortion: Ordinary tape quality
Fan-out:	Recording: one user only. Playback: Parent module, 32 users, easily expandable.
Disc:	Size: .1 x 18.5 inch diameter. Tracks: 32/side, .043 wide, .068 spacing Surface velocity: About 3 ips. Angular velocity: 16 seconds/revolution (3.75 r.p.m.)
Interface Communication:	Recording: Parallel 48-bit words, request and address information to and from system. Playback: Parallel 48-bit word to system, single line equipment reply to other equipment.

1.0 Introduction

It is the aim of this report to provide a description of a multi-user, shared hardware audio response system. The description attempted however, is for a system which has not been completed. Its realization awaits a moment in the future when the system's central component, the flexible surface disc, will be adequately developed. In the meantime however, as a result of the general effort thus far, a firm plan for the overall system has become apparent, and a limited knowledge of the disc has been accumulated. This information is necessarily brief and somewhat tentative since it is contingent upon the continuing development of all aspects of the system. Nevertheless, it is presented now because of its value to those who may become involved with the system or to those of casual interest who desire an understanding of the general nature of the response system.

In this report the description of the overall system will be presented by way of a brief account of the components comprising it and by way of the operation of the system during recording and playback. In addition, some of the salient aspects of the design of the system and the flexible surface disc will be included. A report further elaborating the details of the disc equipment is planned for the future.

2.0 GENERAL CONFIGURATION

Figure 1 gives the general organization of the response system.* As can be seen, the equipment is of two groups; that which is shared, and that which is individually used. The equipment of the shared group is used in parallel or is time-shared with the individual equipments. Included in this group for completeness, but not part of the response system as such, is the central processor and the "other peripheral equipment."

The individual equipments shown in the lower half of Figure 1 can be considered as a kind of terminal equipment required by each user. Their purpose is to control the access of information made available by the shared equipments. Presumably they are limited in nature and can be easily replicated.

Potentially many individual equipments can be tied to the system. Initially there are planned 32. In the event more are needed however, simple fan-out equipment can be provided to make possible many more. The limit to the fan out will depend largely on the quality of the repeating equipment and the loss of performance that can be tolerated.

2.1 Central Processor

The central processor is an ordinary general purpose computer and serves as a control element for the system. Its main activity is to process requests generated within the system and to transmit them to the audio-response system for recalling audio records or for recording new ones.

2.2 Record-Edit Equipment

Found in this group are the audio equipment and digital control circuitry. Their use is for making recordings on the disc and for generating addresses for the recordings during the recording process. Ordinarily during recording, the equipment will be operated on-line or on a time-share basis with the central processor

*A list of block-logic diagrams elaborating figure 1 and other details of the operation and design of the system is included in the appendix. These drawings are not included herein but are on file and available separately.

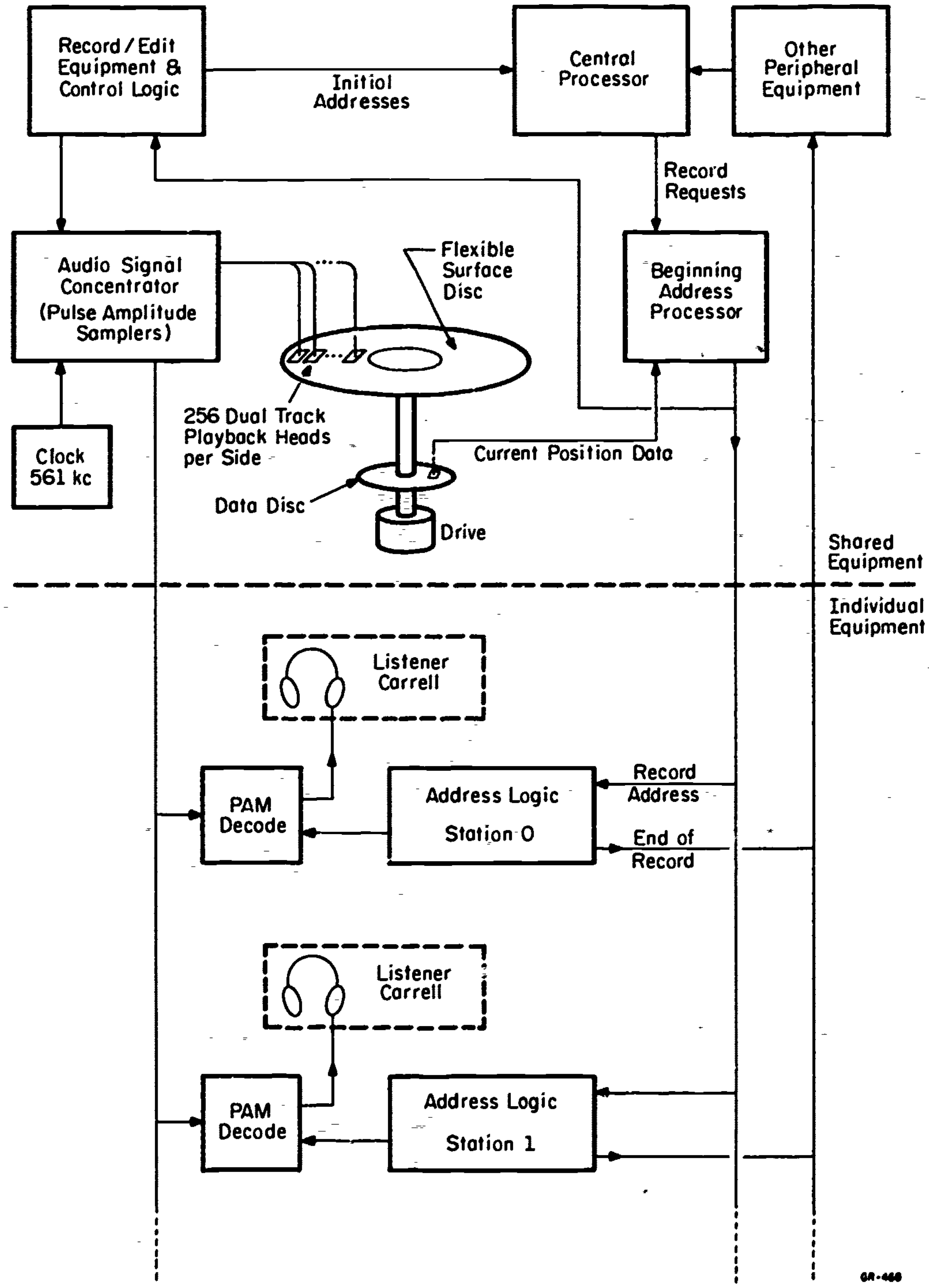

Figure 1. Equipment Organization -- Multi-User Audio Response System

Appropriate beginnings will be made with the aid of the internal control circuitry and the beginning address processor. Visual que signals and pre-start signals will be provided by the control circuitry to facilitate the recording of live or tape generated audio.

2.3 Audio Signal Concentrator

This equipment is essentially a pulse amplitude modulation system that brings about a simplification of distribution of audio among the individual users. The equipment is used in conjunction with the disc and operates in parallel with all individual equipments. In effect, it makes available all the audio from the disc in the form of channels of time-multiplex pulses. One thousand twenty-four audio signals provided by the disc are reduced to 63 channels of pulse amplitude audio. Each channel carries trains of 17 pulses. Sixteen of the pulses represent the audio originating with the heads of each track and one represents the d.c. reference for the channel.

2.4 Disc System

Serving as a multi-signal audio storage unit is the disc system. Central to it is a dual-sided disc outfitted with 512 dual track heads. The heads arranged to form 64 tracks, are spaced one second apart on each track. By turning continuously at a rate of once per 16 seconds, or 3.75 r.p.m., the disc makes the beginning of any recorded information available to some head within 1/2 second on the average. Tracks are overlapped slightly so that continuous track-to-track recordings can be made. A total recording time for all tracks is 1023 seconds. Recordings are made with conventional analog techniques that result in a record-to-playback bandwidth of from 9 to 12 k.c.

2.5 Beginning Address Processor

Because of the continuous turning of the disc, the beginning points of records on the disc are constantly changing with respect to heads on the disc. Providing for the locating of heads with respect to record beginnings is the logic of the beginning address processor. This logic modifies incoming requests to be in accordance with the current angular position of the disc. This modification insures proper head selection when the request is received at the address logic of the individual recording equipments. In addition, the processor screens and additionally modifies requests for proper addressing at track overlap intervals. Requests are always processed quickly and cause little interruption of the central processor or delay to the individual equipments.

2.6 Address Logic

Included in this equipment is digital circuitry which functions during playback to start, continue, and stop the playback process. The circuitry involves counting registers and control circuitry which operates in conjunction with the beginning address processor and the PAM decode equipment. Incoming record requests from the address proces[illegible]terpreted for audio source selection; playback beginning, and play[illegible] duration. In addition, the circuitry has provisions for signalling external equipment at the end of playback.

2.7 PAM Decode

Since audio available at the individual equipments is in the form of time-multiplex pulses, decoding is necessary. Performing the decoding is circuitry of the PAM decode group. Driven by common clock data and data from registers of the address logic, the circuitry yields amplitude varying pulses that represent audio originating with playback heads of the disc. The decoding is such that channels are decoded by track number selections and pulses are decoded by head number selections. Fast switching characteristic of the circuitry makes possible continuous audio from track to track. Audio is recovered through box-carring and filtering of selected pulses.

3.0 OPERATION

3.1 Interface Communication

Parallel data will flow in either direction between the response system and the central processor. Data to the response system will be record requests used in recording and playback. Data from the response system to the central processor will be initial addresses generated during recording and end-of-record signals generated at the end of play-back. Direct flow of data will occur for the record requests and initial addresses. Indirect flow will occur for the end-of-record data through other peripheral equipment.

Record requests sent to the response system will be accepted immediately by the response system. Initial addresses sent to the central processor however need not be accepted immediately. It is only required that any initial address sent be accepted prior to the sending of a new one. The consequences of ignoring an initial address will be to halt the recording process. End-of-record signals, accompanying the stopping of playback, can be ignored.

Word length and bit allocation for the directly communicated data is shown in Figures 2 and 3. The initial record address word contains an 8-bit group for serial numbers, and 16 bit groups for record length and record beginning addresses. These lengths provide for the entire range of addresses and record durations possible with the present system as well as for a numbering for 128 of them. The initial record addresses ordinarily will be generated during recording and stored. Subsequently, address and length information contained within them will be used in the formation of record requests.

The record request word format is similar to that of the initial addresses. Record address and length bit allocation is the same. The remaining bits will be allocated in accordance with the intended use of the word. The key to the intended use are the mode bits.

If recording is intended, the recording mode bit is set to a 1, and the serial number, available in the initial address, is changed or left as is. Equipment identification bits are not needed in addition to the recording mode bit since only one equipment in the system is designated for recording. If playback is intended, only the serial number need be changed to an equipment number identifying the equipment with which playback is to begin.

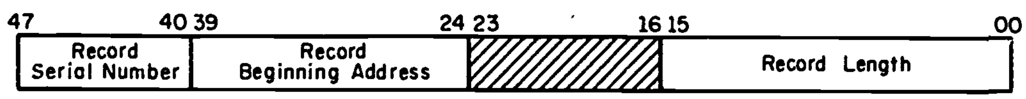

Figure 2. Initial Record Address

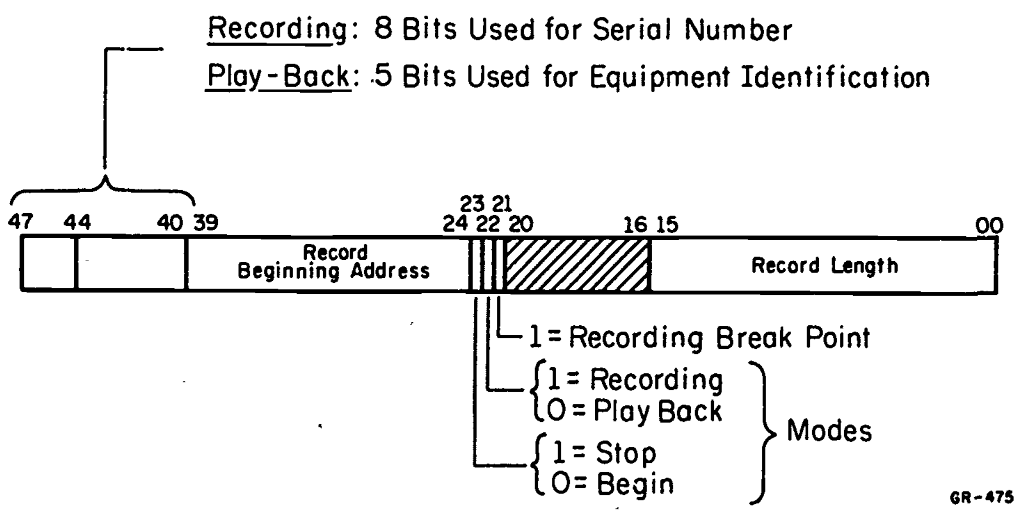

Figure 3. Record Request

For stopping the record request can take a simplified form. To conclude recording, only the mode bits for recording and stopping need be set to 1 To conclude playback only the mode bit for stop and the bits for equipment identification need be given.

For break-point generation, only the recording mode bit and break-point bit need be set to a 1. Recording is uninterrupted by breakpoints.

3.2 Recording

Recording will ordinarily be done on-line, on a time-share basis with the central processor. The function of the central processor during recording will be to generate record requests and to receive initial addresses. Record addresses will be generated in response to manual inputs coming from the recording site and initial addresses will be generated as recording takes place. Record addresses will control the functions of starting, break-point marking, and stopping. Initial addresses will be used in the forming of record requests for subsequent playback or recording.

Recording will ordinarily take place during the absence of multi-user playback. If playback during recording is desired however, the records on the track where recording was begun must be selected judiciously. This is necessary since one playback head on each track of the disc is used as a recording head during recording. The proper selection, for the purpose of monitoring, will be made by simply calling the play-back within 16 seconds after the onset of recording. If need be, provisions can be made to cause general avoidance of the recording head during playback.

The audio source used at the onset of recording can be live or programmed as from auxiliary tape equipment. In either case, the starting of source audio must be synchronized with the incidental arrival of the starting address under the recording head on the disc. The instance of arrival may be any time within 2 to 18 seconds after a request specifying a starting address is received by the equipment.

To assist in the synchronization of source and disc, three visual cues will be made available to live sources, and two electrical cues to auxiliary equipment sources. The first cue will be visual only and will be given the instant a record request is received. The second will be visual and electrical and will be given 2 seconds prior to the onset of recording. The third and last will be visual and electrical and will be given at the onset of recording

Once begun, recording may be interspersed with break-points identifying junctures in the source audio. These can be given by manual means by way of tones generated by the auxiliary tape equipment, or by way of record requests Complete stopping can be accomplished in a similar way or by letting the recording run to the limit specified by the length information of the record request first received for recording.

With the generation of each break-point or the stopping of the recording altogether, an initial address will be signalled to the central processor. Contained in the very first initial address sent will be the serial number and address information of the record address used to instigate recording. The length information, however, will be the duration of the recording at the time of the break-point. If no breakpoints are generated during recording, an initial address involuntarily signalled upon stopping, will be considered the first break-point.

In the instance when more than one initial address is generated during recording, serial numbers of succeeding initial addresses will be automatically incremented. Also, for any particular initial address after the first, address information will be that derived at the time of the previous break-point. The length will be that of the recording time included between the previous break point and the one generating the particular initial address.

3.3 Erasure

Erasure will automatically accompany recording. It will continue through break-points but will stop at the length specified in the request instigating the recording. Premature stopping, unlike length stopping, will cause an overrun of erasure of about 1/8 second. This is because the erase heads are displayed 1/8 second from the recording heads.

3.4 Playback

Playback will ordinarily be done on-line also, on a time-share basis with the central processor. Requests arising within the central processor typically in response to keyset inputs via other peripheral equipment are directed to the response system and its individual equipments. There, they bring about the starting or stopping of playback. Many requests can be sent within a short time and cause the simultaneous operation of many equipments. Any or all may playback the same or any record.

Playback is instigated by sending a record request to an individual equipment. It will be accepted immediately. Upon receipt however, it may not cause the onset of audio. A small delay, perhaps 1/2 second, but not more than 1 second, will ensue first. This is to give time for the record requested to come under one of the heads available for play-back on the disc. Once begun play back can continue until the end is reached. The end will normally be determined by the length information of the record request. The end can be brought about prematurely, if desired, by sending another record request calling for stop. Either way, an end-of-record signal will be sent out from the individual equipment signalling the end of playback.

3.5 Access Times

Illustrated in Figure 4 are the response times pertinent to the execution of record requests received by the response system. In light of the discussion of recording and playback operation the diagram is self explanatory except for the address processing interval. The additional 10μs, making for an occasional 20μs in address processing is needed to resolve a conflict between record address inputs and code wheel inputs to the beginning address processor. The possibility of conflict arises for only 10μs every 1/64 second and at most causes a 10μs hold-off of one or the other inputs.

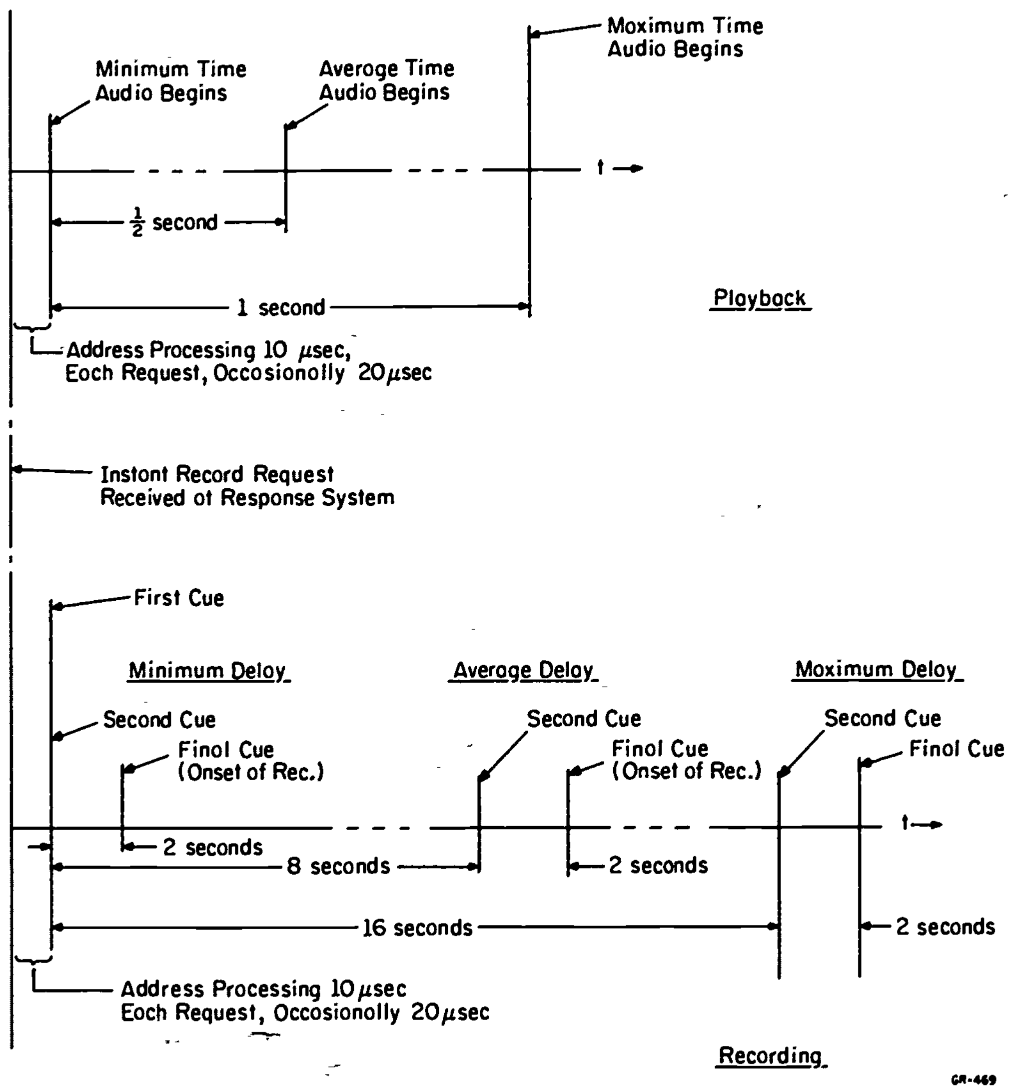

Figure 4. Response Time Diagram

Initial address execution, record address generation and other factors involved in the overall performance of the system are not discussed. For those interested, a limited discussion of a related multi user instructional system and factors affecting its overall response is listed as a reference.*

* Bitzer, D.L., and Braunfeld, P., "Description and use of a Computer Controlled Teaching System," Proceedings of the National Electronics Conference, pp. 787-792, (October, 1962).

4.0 SYSTEM DESIGN

4.1 Addressing

4.11 Disc Address Structure

Tracks and increments along a track are the basic quantities considered in forming addresses for the present system. Each increment along a track is equivalent in time to 1/64 second. Sixteen seconds worth, or 1024 of the increments completely fill each track. Their total for 64 tracks, if placed exactly end to end would be 1024 seconds. However, as a practical matter they are made to overlap slightly to provide continuous audio during playback. As a consequence, their total length is reduced to 1023 seconds when 1/64 second per track is chosen for overlapping.

How the overlapping is done and the increments numbered is shown with the help of Figure 5. There, for example, track Ø is seen to contain record addresses ranging from Ø to less than 16. Track 1 is seen to contain record addresses ranging from 15 63/64 to less then 31 62/64, and so on up to track number 63 where the range ends at less than 1023. The overlap intervals for the forgoing are seen to be: 15 63/64 to 16 for track Ø, 31 62/64 to 31 63/64 for track 1, and so on.

By virtue of the increment numbering expressed in Figure (5), the address of the beginning of any record can be expressed as a 16 bit binary number. The first 10 bits of the number give the distance of the record from the beginning of the track. The remaining 6 bits give the number of the track containing the record.

Because of the overlapping, incremental continuity from the first 10 bits with respect to those remaining is lost. That is, the first 10 bits represent increments numbered mod 1024 whereas the remaining 6 bits represent tracks numbered via increments, mod 1023. If tracks were numbered via increments mod 1024, continuity would exist and an address would indicate the exact time in 1/64th second increments from the beginning of the first track.

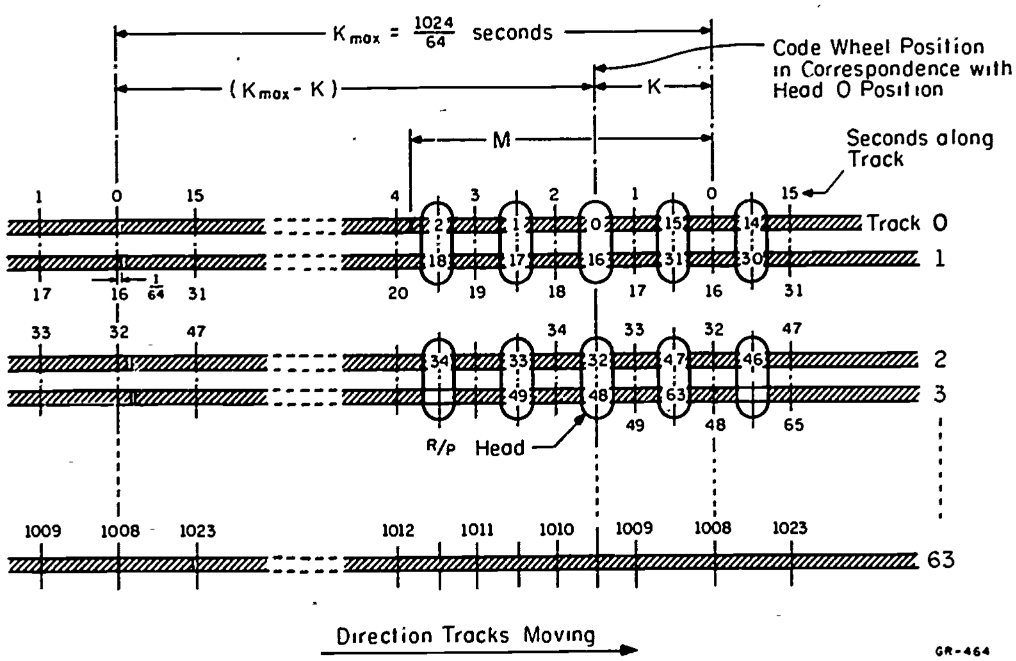

Figure 5. Disc Head-Track Organization

4.12 Record Address-Head Locating

While the disc is in motion, the location of a record along a track with respect to its next, nearest recording or playback head requires two kinds of distance information: (1) the distance between the beginning point of the record and the beginning point of the track containing it, and (2) the distance between the point of contact of the R/P head and the beginning point of the track involved. The first is readily available as an interpretation of the record address itself. The second, however, must be obtained from the readout of a code wheel attached to the disc shaft.

In the present system, a wheel that gives 1024 one sixty-fourth second values per revolution is used. The orientation of the device is such that its readout values correspond exactly with the addresses of the zero track of the disc. A more detailed description of this device is found in Section 4.2.

A manner in which the code wheel readout information is used to locate playback or recording heads is explained with the help of Figure 5. For the purpose of illustration, the disc tracks shown are repeated to simulate their closed form provided by the disc. Given the arrangement shown and a 16 bit record address, the head next to acquire the beginning of a record specified is found through the relation:

$$H = (Kmax-K) + m$$

Where:

H = Head number (h) & countdown in sixty-fourths of a second

Kmax = Maximum value of the code wheel = 1024

K = Current value of code wheel

m = Record address bits Ø through 9

As seen in Figure 6, bits 6 through 9 are used to locate the head nearest the record requested during playback whereas none, implying Ø, is used for locating the recording head. The reason for this is that only one head (head Ø) on each track is specified for recording purposes. The countdown referred to as part of H is the actual time left before the record beginning comes under the record or playback head at the instant the record request is executed. In the case of recording, the countdown will be a maximum of 18 seconds, and in the case of playback, the countdown will be a maximum of one second.

It is worth noting that the number of heads used per track are related to the most significant bits of the Ø to 9 group. For simple configurations, the quantity of heads per track is one more than the maximum value of the bits chosen to represent them. The remaining bits are, of course, used for countdown.

4.13 Overlap Interval Switching

As mentioned in Section 4.11, overlapping of the tracks occurs at particular intervals along the tracks. These points, it is noticed, begin at incremental distances from the begin-end point of track zero. The distance, it is further noticed, is related to the track numbers. For example as seen in Figure 5 track Ø has an interval which begins 1/64 second near its beginning. Track 1 has an overlap point which begins 2/64 second near the beginning point of track Ø. Track 2 has an overlap point which begins 3/64 second near the beginning point of track Ø, and so on.

This correspondence between the onset of the overlap point and the track number is made use of in the implementation of the logic which governs head switching during recording and playback. The essentials of such an implementation can be seen in Figure 7. There, a counting register initially holding the track number, is made to step each time coincidence is achieved between its value and a code wheel readout with which it is compared. The coincidence, and hence, the overlapping precesses by 1/64 of a second for each revolution of the code wheel. This is due to the use of the 1's complement of K in conjunction with the counting register. That is, since the zero value of the one's complement and the zero value of the true value, (K), of the code wheel are displaced by 1/64 second, coincidence occurs 1/64 second earlier each revolution.

The track number held in the counting register and those held in the auxiliary registers shown in Figure 7 differ in value momentarily. The exact duration of the difference is determined by the delays regulating the moment when the auxiliary registers can take on the contents of the counting register. In the case of recording, the delay is 1/64 second and allows for completion of the track on which recording was taking place prior to overlap. In the case of playback, the delay is 1/128 second and allows the mid-point of the overlap to be reached before switching tracks. Implied in the switching is the fact

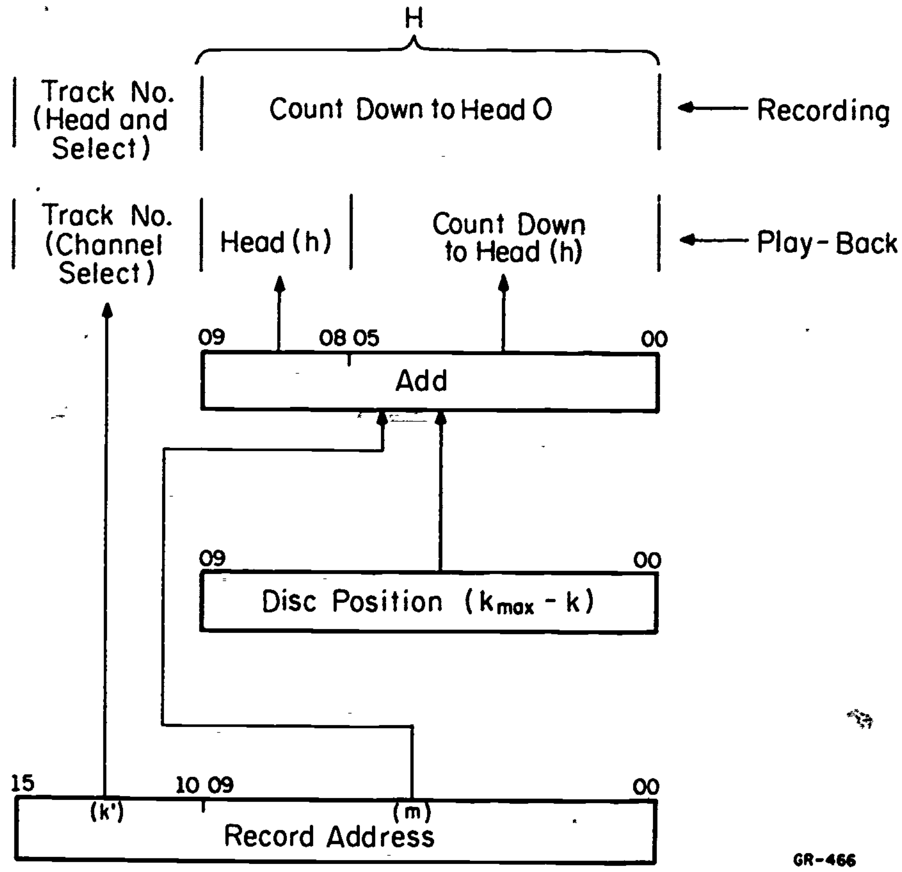

Figure 6. Head Selection

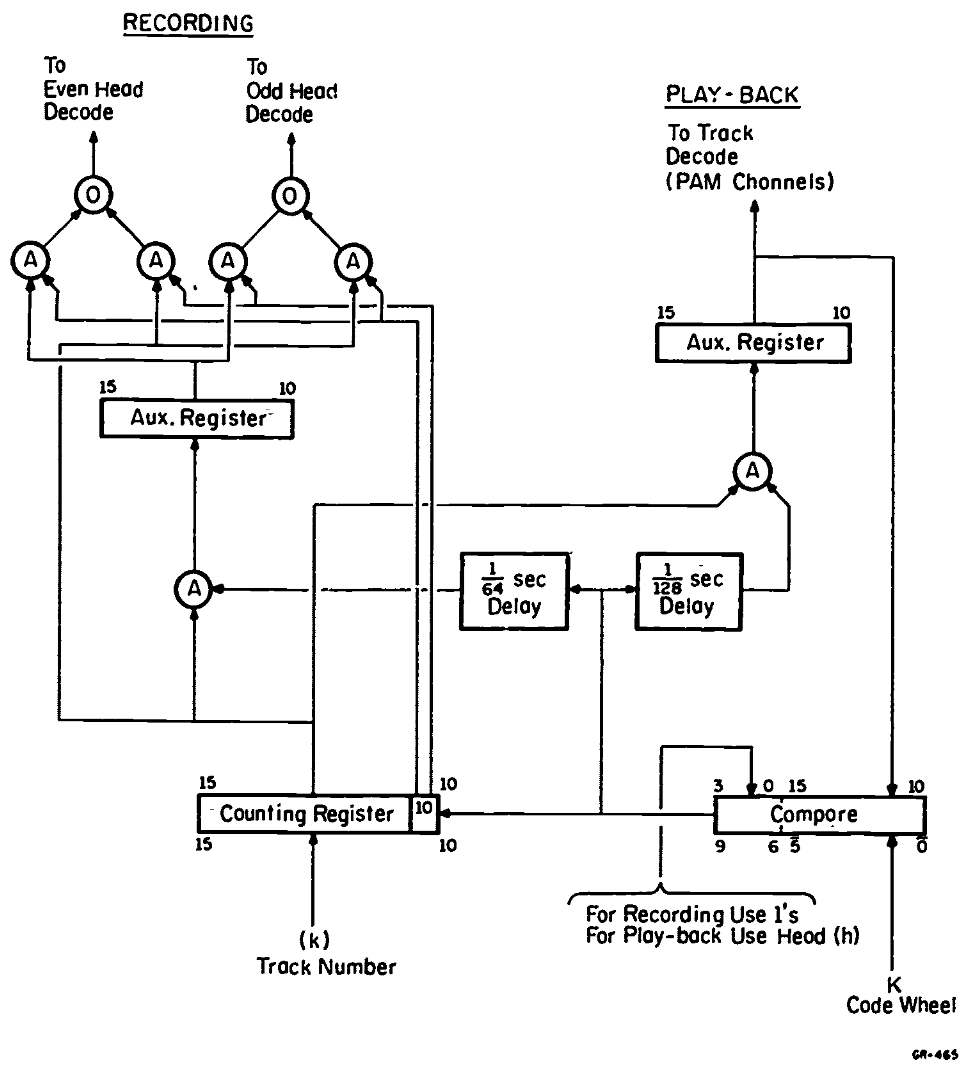

Figure 7. Track Switching

that corresponding head numbers will be retained. That is, for recording, only head Ø of succeeding tracks is used, whereas for playback head (h) and corresponding head (h + 16) of the succeeding track is used.

4.14 Overlap Address Processing

All addresses contained in addresses falling on overlap intervals which call for immediate overlap switching will be avoided. This will be done to circumvent timing difficulties associated with the arrival of these addresses. The addresses will be avoided in two ways: (1) by not generating them as initial addresses, and (2) by modifying them as they are received by the system. That is, during recording the first initial address generated, if it happens to fall on an illegal overlap interval, will be made to be the address for the next track ordinarily switched to during overlapping. For the instance where illegal requests are forthcoming by other means, they will be modified to the next track ordinarily switched to during overlapping.

To provide for proper address modification, the logic of Figure 8 is used. All requests arriving at the system are processed by this logic. Those with illegal addresses are made acceptable by incrementing the track number portion of the address. This, in effect, provides overlap switching beforehand.

The basis for the operation of the logic shown is the fact that all overlap intervals fall within the last one-second of rotation of the disc and that the overlap interval is related to the track number. That is, by comparing the groups of address bits in the manner shown it is found: (1) whether or not the record address falls within the last one-second of rotation of the disc and, (2) whether or not the address falling within the one-second increment falls within an increment that corresponds to the track number. If both the foregoing are answered in the affirmative, the record address is illegal and is avoided by increasing the track number by one. This changes the starting point to the corresponding increment of the next track. No loss of information is caused by this since the overlap intervals are recorded simultaneously.

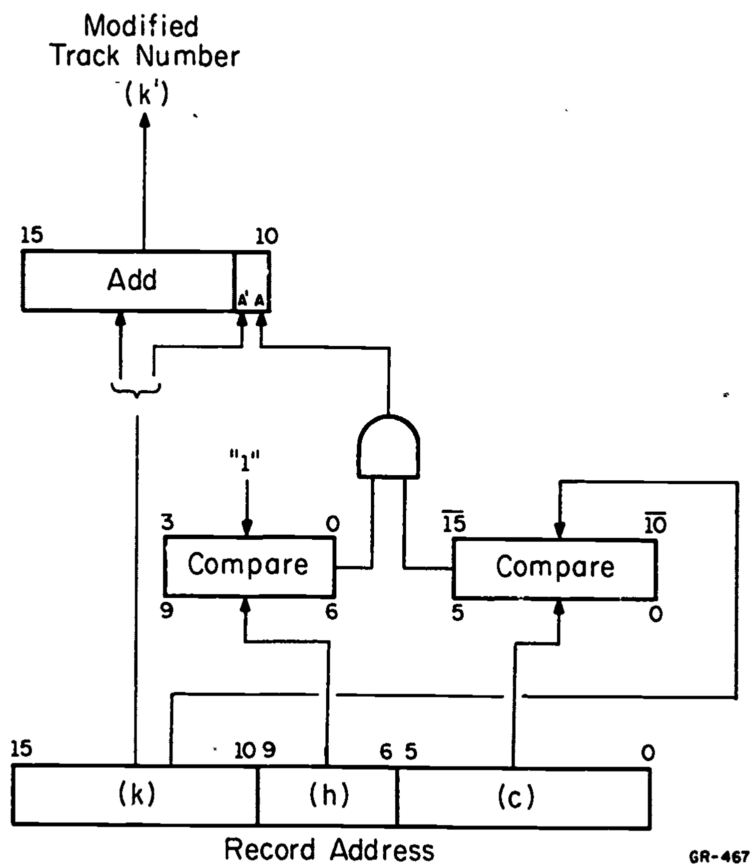

Figure 8. Overlap Address Processing

4.15 Overlap Interval Length

The length of the overlap interval of the discussion thus far can be greater. Larger values can easily be obtained by choosing different comparison values used in track switching and initial address processing. For example, choosing code wheel bits 1 through 6 and 7 through 9 for comparison in Figure 7, and bits 1 through 6 for (C), 7 through 9 for (h), and 10 through 15 for (K) for comparison in Figure 8, will effect a doubling of the overlap interval. The interval can be doubled again by another similar pattern of shifting.

4.2 Code Wheel

The "code wheel" as it has been termed in this report is a generator which produces pulses every 1/64 second and angular position data. The angular position data is used in addressing and the pulses are used in determining starting delays and record durations. Figure 9 gives a block diagram of the generator.

As seen, it is basically a 13 stage counter, reset by the disc zero reference and driven by the single track wheel attached to the disc shaft. The reset comes once perrevolution of the disc and the driving pulses come at a rate of 8192 per revolution of the disc. The last 10 stages of the 13 available provide for angular position data. The first 3 stages however, do not. Their purpose is simply to increase the total count so as to allow for acceptable synchronization of the angular data and the disc addresses.

For the present scheme, the synchronization accuracy will be one part in 8 of the smallest increment or ± 1/8 of 1/64 second. Synchronization of the disc and counter in the manner shown allows for an arbitrary angular alignment of the disc when mounted. The alignment is made correct within one turn after mounting.

4.3 Audio Signal Processing

4.31 Audio Signal Concentrator

The use of pulse amplitude modulation techniques for the purpose of concentrating or bringing together a number of audio signals for easy transmission and orderly distribution is well known. With regard to the present system,

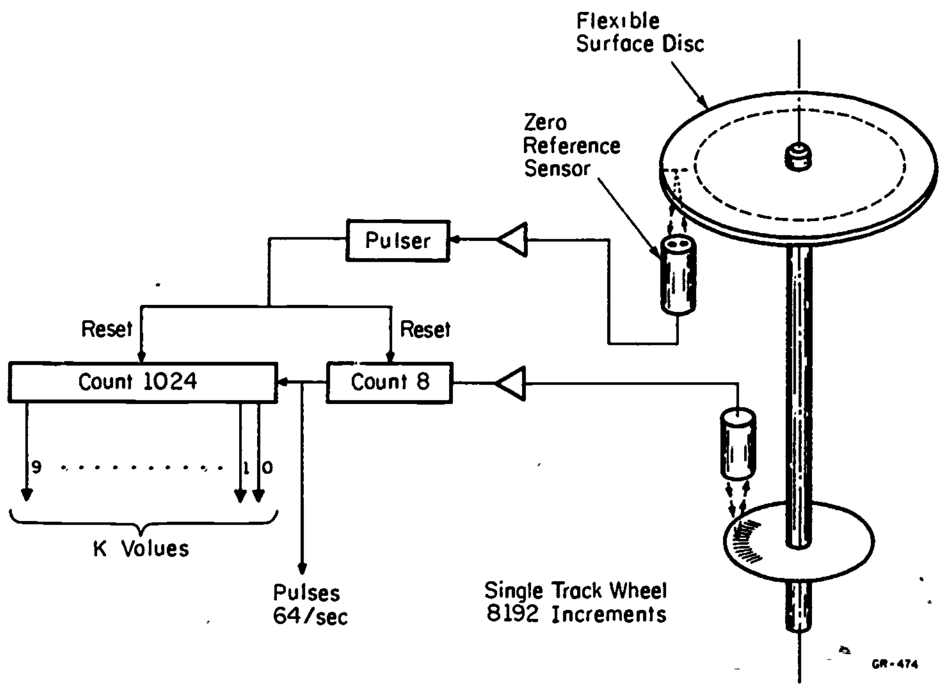

Figure 9. Code Wheel

the 1024 audio sources available on the disc are reduced to 64 channels, each carrying 17 pulse trains. Of this periodic group of 17, sixteen are used to carry the audio and one is used to establish the d-c reference level for the audio group.

The audio carried by the sixteen pulses is restricted to that originating with a particular track. By this restriction, channel numbers and track numbers can be made to correspond directly. Correspondence is also made between the position of the pulses carrying audio and the play-back heads they represent. With the correspondence of channels and tracks, and pulses and heads, audio from any head is made available through a simple track and head number specification. Figure 10 gives a configuration of a pulse amplitude modulation system having characteristics in keeping with the foregoing.

4.32 Channel Considerations

Frequency memtioned with regard to the applicability of an audio system is the upper limit of the frequency response characteristic of the system. A value of 3 or 4 khz is generally accepted as being suitable for most applications requiring only ordinary voice responses. However, 10 khz or more may be required for improved intelligibility important to language instruction, or for applications in general.

The limit of the frequency response of the present disc equipment while operating with only conventional recording and playback circuitry is between 9 and 12 kc. That is. the values obtained were with circuitry that did not include pulse amplitude components. It is expected that their being included later however, will have little effect on the bandwidth values given. This is due mainly to the 33 kc sampling rate which was chosen to be well above the minimum needed for full bandwidth performance. The 33kc rate is also high enough so that easy pre-sampling band limiting and detection filtering can be accomplished, but not so high as to make sampling difficult. Figure 11 gives a spectral representation of the sampled signal. The attenuation characteristics are determined by the pre-sampling filtering to be used and do not represent the total attenuation expected. Higher values will actually be realized when the audio cut-off characteristics of the disc audio circuitry are included.

Specifications for the individual amplitude sample pulses and other associated pulses are shown for a typical channel pulse train in Figure 12. The 1.74μs width is estimated to be sufficient to allow for adequate circuit settling before strobing so as to keep inter pulse cross-talk at low levels.

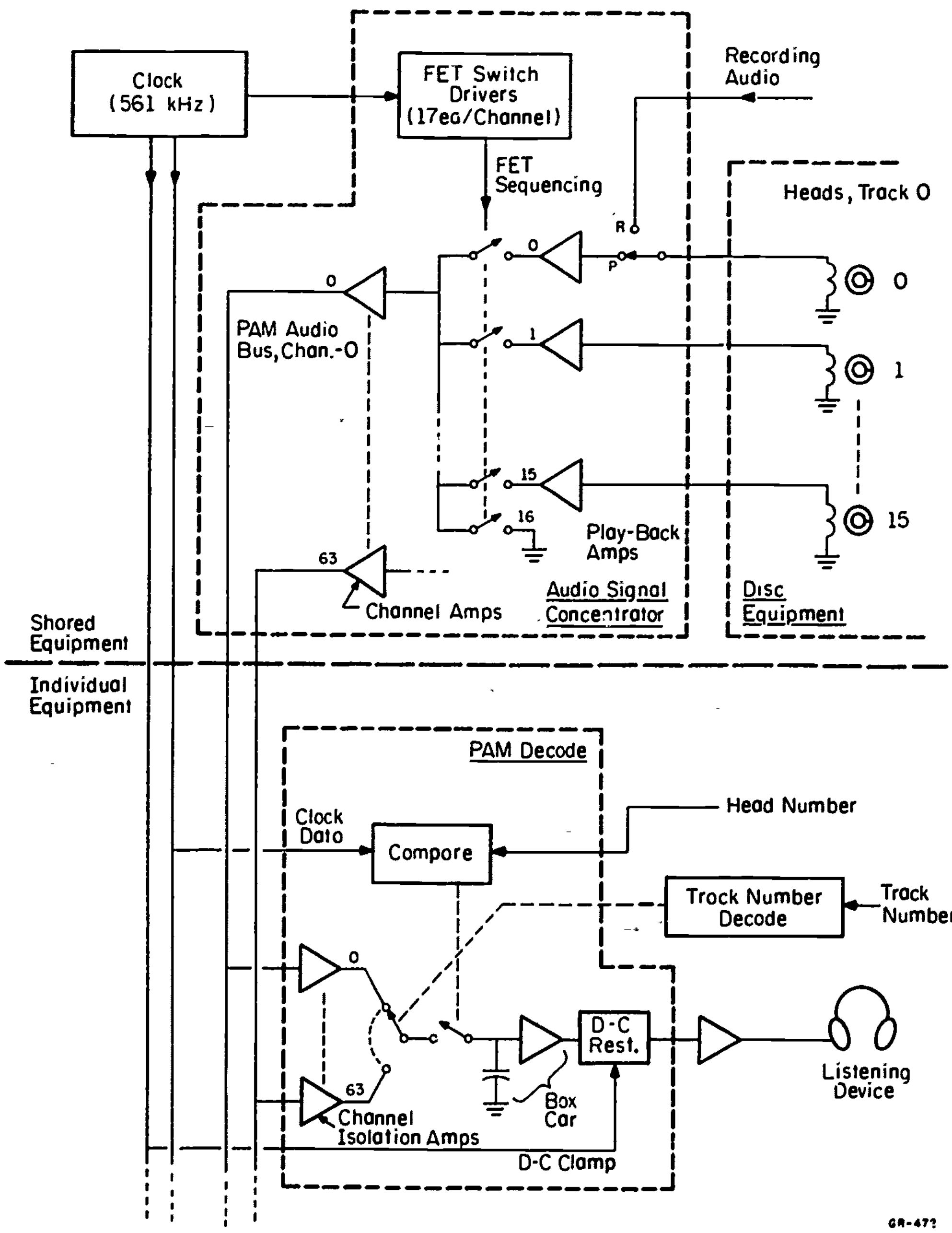

Figure 10. Audio Signal Processing

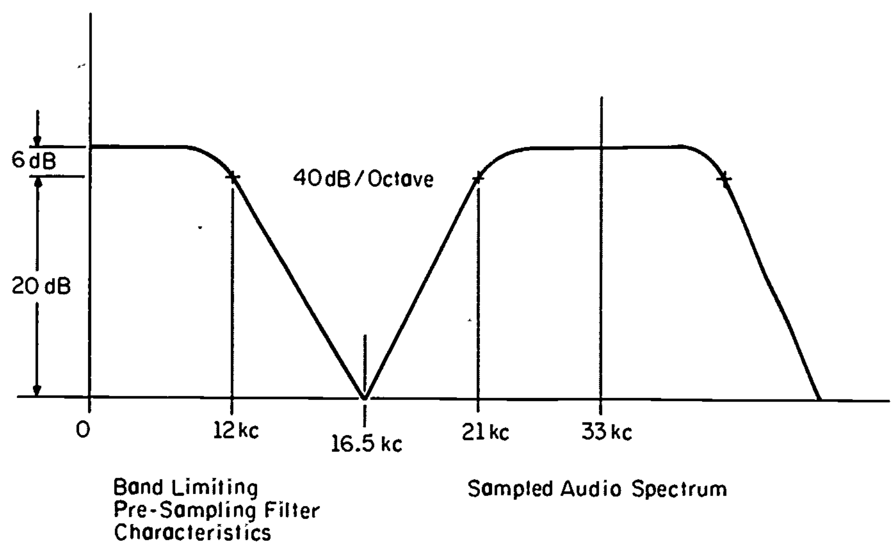

Figure 11. Channel Characteristics

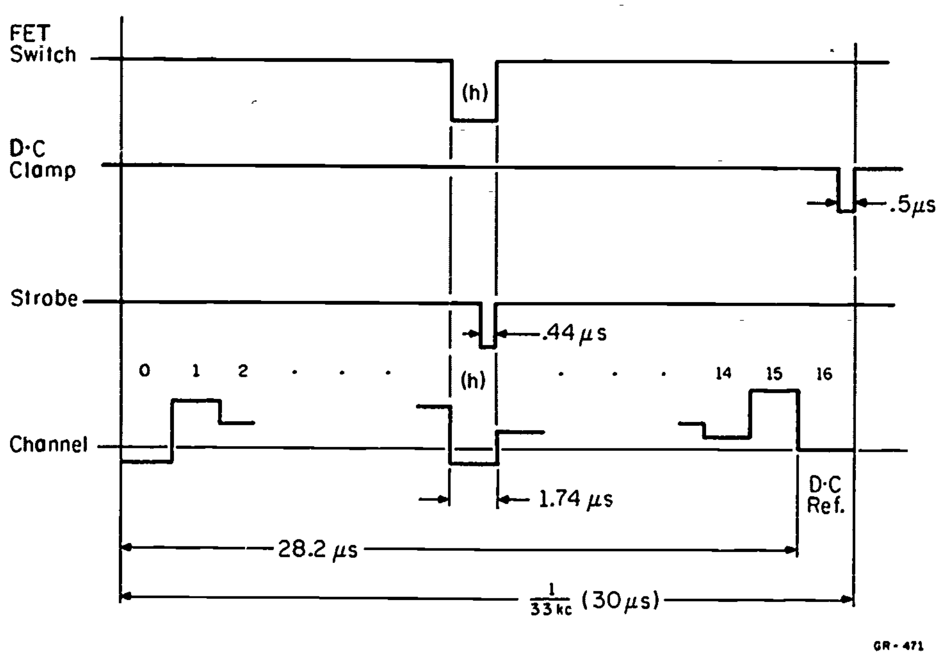

Figure 12. Channel Pulse Specifications

5.0 Disc Equipment

5.1 Flexible Surface Disc

The flexible surface disc is a device that has a flexible, air supported surface. This novel feature enables it to accommodate small irregularities in head-to-disc spacing that may arise from variations in disc flatness, flexible surface flatness, or alignment of heads in contact with it.

Figure 13 gives a simplified view of a disc installation for the present system. The disc shown there consists of a stiff base each side of which contains annular cavities covered with a flexible, oxide-coated film. Included in the base are passageways for air providing for movement of the surfaces against or away from the heads.

Shown in Figure 14 is an enlarged view of the cutaway section of the disc. Illustrated is the manner in which the flexible surface is made to contact the transducer pole pieces. Only the lower portions are shown of the pole pieces of a group of 4 dual track heads. Their position is such that they are close to one another, not too close to the edge of the disc and vary somewhat in their vertical alignment.

The surface and outer edge of the disc is shown in three positions: A, B, C, representing irregularities in the movement of the disc surface during operation. A might be an average position of the surface and would be that which the transducers would be aligned to. B and C are the limit positions of the upper surface of the disc which in practice would not be running perfectly true. It is noted that because of the supporting forces, depicted by small arrows, provided by the air under pressure coming through the passage ways at the right, the film is pressed against the transducer faces as shown. Even when the surface is at A or B, the film flexes so that it remains in contact with the pole pieces.

5.2 Surface Control

Under conditions of continuous contact, a constant but small pressure of air of about 1cm of water is required to maintain the flexible surfaces in contact

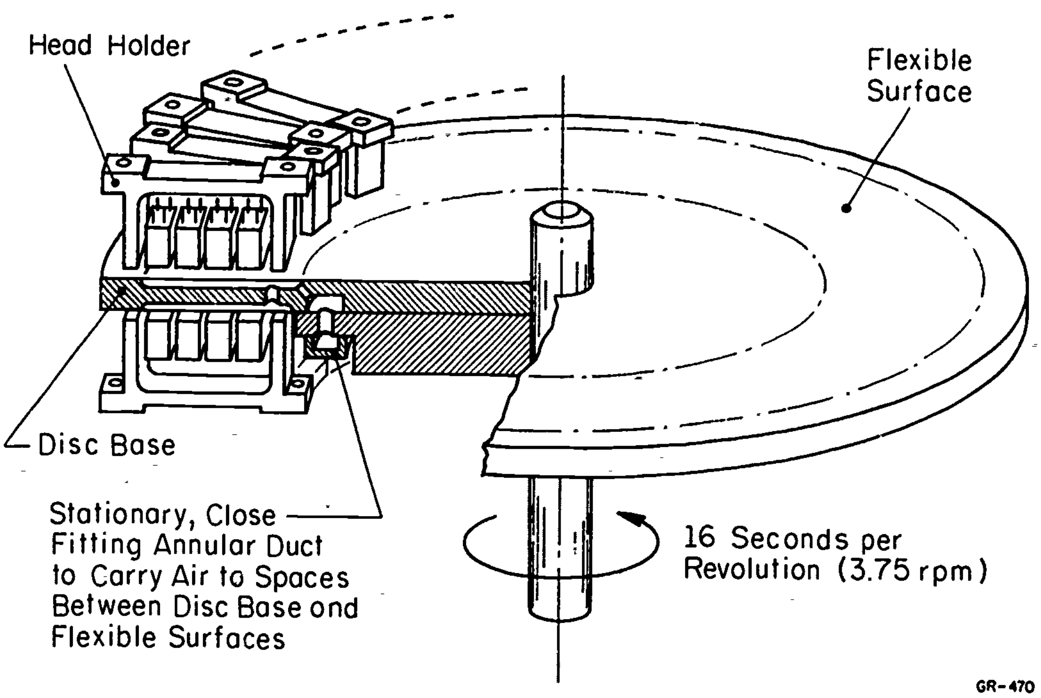

Figure 13. Flexible Surface Disc, Simplified View

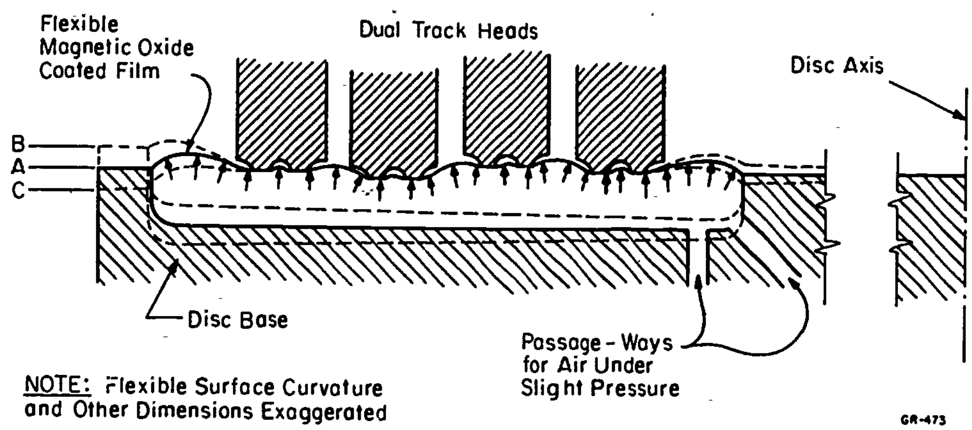

Figure 14. Flexible Surface Operation

with the heads. Under conditions of transient contact, when the surfaces are moved quickly to or from the heads, a pressure boost to the air is required to hasten its flow to or from the surfaces.

Transient operation is contemplated so as to keep head and surface wear to a minimum. That is, it is foreseeable that idle periods during operation may total to be a non-trivial fraction of the life-time of heads or surfaces. This being the case, it seems prudent at least to provide for the separation of heads and surfaces when they are not needed.

5.3 Head-Track Configuration

Dual track heads, totalling 512, are positioned in 16 groups of 16 per group at equal intervals along each of the flexible surfaces. The heads of each group are mounted in 4 equally spaced holders each holding 4 heads. Each of the groups of 16 heads is positioned over 32 tracks common to all groups on a side. Only one group for each is shown in Figure 13.

The foregoing concerns the arrangement of heads as they are used for playback. For recording, the arrangement is to have one head of each group serve as both a playback and recording head for each track. For erasure, the arrangement is to have an additional erase head in each group mounted in close proximity to the head chosen to serve as a recording and playback head. The closest proximity possible in the present design will result in a time spacing of 1/8 second with respect to the turning of the disc.

The track width and spacing compatible with the playback and erase heads used with the disc is .043 inches and .068 inches respectively. Thirty-two tracks span the central portion of each surface. A .25 inch margin is left between the tracks and inner and outer circumference of the flexible surface. The total radial span of the flexible surface is 2.65 inches.

The playback and erase heads used with the disc are compact, 4 track stereo types found in conventional tape recorders. The playback heads are reworked to slightly relieve the poles of each head. In so doing good contact with disc surface is insured. Similar reworking of erase heads was found unnecessary.

6.0 Appendix

6.1 Disc Fabrication

The choice of available materials for the disc base and flexible surface is limited. Fortunately however, what is available is quite satisfactory. The flexible surface material is polyester audio tape stock of high quality. The brand used, (Memorex type 25), is satisfactory with regard to coating properties, flatness, and smoothness. The disc base materials is .1 inch flat stock aluminum or magnesium and is cut to a diameter of 18.5 inches.

The shallow annular cavities are formed to a width of 2.65 inches and a depth of .02 inches using the technique of chemical milling. This method avoids to a great extent surface strain distortion attending other methods of metal removal.

Attachment of the flexible surface to the base is done by way of suitable epoxy adhesive. Prior to its application and the mating of the surfaces, the flexible surface is drawn gently taut and abraded in the areas that contact the base. Abrading was found necessary for reliable use of the epoxy in the adherence of the flexible surface to the base.

6.2 Block-Logic Diagram List

Drawing Number	Title
GS-536	SHARS A Multi-User SHARED HARDWARE AUDIO RESPONSE SYSTEM - Equipment Organization
GS-537	Input, Address Processing, Code Wheel Logic
GS-538	Record-Erase Logic
GS-539	PAM Audio Clock-561KC-Logic
GS-540	Individual Equipment-Playback-Logic

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13. ABSTRACT

A new flexible surface disc device serves as a basis for the design of a computer operated multi-user shared hardware audio response system. The new disc device employs a slow moving flexible, air supported surface in contact with a large number of heads. Relatively instantaneous distribution of audio from any portion of the disc to any of the users is accomplished through the use of pulse amplitude modulation and digital techniques. The principle of analog recording and fixed heads in contact with the flexible surface allow for a reasonable recording capacity and general design economy. A simple scheme for switching heads electronically allows for recording messages longer than one turn of the disc. In the report, a description of a system currently under development is presented by way of a brief account of the components comprising it and by way of the operation of the system during recording and playback. Some of the salient aspects of the design of the overall system and the new disc component are included.

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Electronic recording & playback						
Flexible surface disc						
Multi-user systems						
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